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Contingent Convertible Debt: The Case Study of Banco Comercial Português

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Section I – CoCo's and BCP

In this work we will be analysing the Contingent Convertible Debt that Banco Comercial Português S. A. (BCP) has in its capital structure.

The Portuguese Economy had been facing structural problems since the beginning of the 2000s. These became evident as with 2011 sovereign debt crisis, investors started attributing different risk levels to the countries of the Eurozone, pricing Portuguese sovereign debt lower than the average. As the Portuguese economy slowed down in the early 2010's, domestic banks saw their interest margin shrinking while domestic loan defaults and investment provisions began imposing heavy losses on their accounts. While financial markets had not yet recovered from the 2008 crisis, the sovereign debt crisis along with the staggering of the Portuguese economy created barriers for domestic banks to finance themselves. In the beginning of 2012, Banco Comercial Português (BCP) considered it would not be able to raise enough capital in order to fulfil the minimum capital requirements tightening established by the Bank of Portugal until the end of the year. The Portuguese Government stepped in and lent the bank €3 billion, while also rescuing Banco Português de Investimento (€1,5 billion) and Caixa Geral de Depósitos (€0,9 billion), on June 29th 2012. The loan was established as a Contingent Convertible bond – a young form of hybrid debt – which would convert to equity in case the banks were not able to maintain capital levels above the minimum or the regulator – the Bank of Portugal – decided that banks required more capital.

Contingent Convertible (CoCo) debt issues began with the Llyods Banking Group in 2008, having been followed by Rabobank and Credit Suisse. A hot debate soon began among academics concerning the automatic recapitalization features of the

bond as well as the incentives these could impose on the issuer in terms of risk management and corporate governance, leading former Federal Reserve chairman Ben Bernanke himself to appraise the bond (Koziol and Lawrenz, 2011). The interest garned around the CoCo comes from the fact that conversion is mandatory, as opposed to a straight convertible where the holder decides to convert as a part of its profit maximization problem (Sundaresan and Wang, 2010). By tying the trigger level to when the bank lacks capital, recapitalization takes place as a way to help the bank getting better financing conditions once again. The incentive imposing feature comes from the conversion terms. These can be set in a way that conversion transfer value from shareholders to CoCo holders, thus making conversion undesirable (Glasserman et al., 2013). However, academics have argued that these CoCo's can also bring problems as the firm may decide to increase the risk of its returns, in an attempt to avoid conversion as in the case of bankruptcy. For a more in depth discussion on the literature available about CoCo designs please see Appendix 1.

Millennium BCP is a Portuguese bank, very exposed to the domestic economy (59,9% of the business, as of June 2013), which has been in recession for the last years, putting downward pressure in the bank's profits. On the other hand, operations abroad, namely in Poland, Mozambique and Angola, are being profitable and their growth is expected to increase in the near future, partially compensating for the domestic losses. Overall, the bank had been facing high losses, especially due to provisions (Exhibit 1B), compromising its capital buffer. In order to comply with the minimum capital requirements imposed by the Bank of Portugal (Core Tier 1 ratio above 10%, as of 2013), on June 2012 BCP asked the Portuguese government for a bail-out, which lent the bank €3 billion in contingent capital. As a part of the agreement, BCP had to raise

additional €500 million in equity on its own, with the government's backing in case the capital markets did not finance the whole amount, but fortunately they did (October 2012). The successful emission at €0,04 per share raised the total amount of shares from 7207 million to an astonishing 19707 million. As of June 2013, the biggest shareholder participations were Sonangol (19,44%), followed by Sabadell (4,27%), Berardo (3,06%) and EDP (2,99%) while the sum of all participations above 2% account for only 34,66% of the total equity – evidence for a relatively diluted shareholder structure. The main balance sheet entries can be found in Exhibit 1B..

Our work will go as follows: in Section II we will be analysing the specific covenants of the contract between Banco Comercial Português and the Portuguese Government; in section III we will be conducting a simple break-even analysis on the bank's provisions in order to access the progress of the bank in avoiding CoCo conversion; in Section IV we will building a simple model in order to price both the CoCo and the bank's stock, followed by a parameter sensitivity analysis; finally, in Section V we will be summarizing our main conclusions.

Section II – The CoCo contract

Exhibit 2A summarizes the main characteristics of the lending to Banco Comercial Português.

The bond has several additional covenants, which we will also be discussing.

The first thing we notice is the size of the issue. At the time of the issue, this amount accounted for 3,2% of BCP's total assets (June 2012) and about 1,7% of the Portuguese GDP (as of 2011). It is worth mentioning that this bank received the greatest capital tranche among all the rescued banks (Diário da República, **Despacho n.º 8840-B/2012)**

Core Tier 1 Relationship

The CoCo bond was already qualified as Core Tier 1 equity at the time of the issue, differing from most of the issues so far. Therefore, even though the bank becomes better capitalized after conversion, this ratio will not recover at that point so the access to capital markets should not improve substantially since creditors take the Core Tier 1 ratio as an important investment variable. This negative outlook about conversion can be an incentive for proper management. One must not forget, however, that this feature was necessary at the time, as the bank needed to increase its Core Tier 1 Equity immediately at the time to comply with minimum capital requirements and the market was not willing to help. Without the CoCo requirement, the bail-out would have eventually resulted in the nationalization of the bank directly, meaning that this bond is actually a way of gaining extra time and provide BCP with the chance to avoid being taken-over by the government. Essentially, the appraised bail-in feature is not present within this contract as the government was the lender (bail-out).

Additional Issuance of Equity

As a covenant to the bail-out, BCP was forced to issue additional €500 million in equity on their own, while the government would supply any amount that the market did not subscribe. This is a positive point for the contract, as academics argue that the most benefits of CoCo's are obtained when these are issued along with straight equity (Glasserman et al., 2013).

Coupons (continues)

On absolute value, coupon rates are very high – a characteristic of subordinated debt. While on the one hand we can say that the Government was compensating itself for the conversion risk, if we take a close look at the BCP's CDS spread curve at the time (Exhibit 2B), we notice that the market was requiring a lot higher interest rates. Theoretically, it means that the government expected to make a profit from conversion, compensating for the coupon cancellation and the lost principal. We will soon come back to this.

The bank is also allowed to pay coupons in shares, causing a small dilution. By doing so, the coupon payment is not tax deductable, by definition. On the other hand, the bank could make use of it in an attempt to avoid a very dilutive conversion in exchange for a small dilution, while actually increasing Core Tier 1 Equity. The failure to pay a coupon results in mandatory conversion but we consider this feature to be rather irrelevant, since managers can use the previous condition as a last resort. Conversion would also be forced if a coupon payment could lead capital requirements to go below the minimum required but, once again, the bank will pay in shares if it avoids the full conversion.

Conversion Fraction

Conversion of principal is full, considered as a good feature of the contract according to the literature (Calomiris and Herring, 2011). As an additional penalty, if conversion takes place in between coupons payment dates, accrued interest is also paid in the form of shares, according to the same formula of coupon payments in stock (5% discount).

The trigger

Contractually, the CoCo actually has a dual "and/or" trigger (conversion takes place if the accounting minimum capital requirements are not being satisfied "and/or" the regulator states conversion is needed). The CoCo triggers if minimum capital requirements established by the Bank of Portugal (BdP) and the European Banking Association (EBA) are not met. As of today, the requirement for Portuguese banks is holding a Core Tier 1 Ratio of at least 10%. The main problem with this trigger is its lag in determining recapitalization needs. Calomiris and Herring (2011) also argued that Risk-Weighted Assets is not a good measure of risk since it is more qualitative than quantitative. In principle, the regulatory trigger should fill gaps in between financial statements (see Appendix 1). A reason of concern is that the trigger is not fixed, as it should be for a proper CoCo (Spiegeleer and Schoutens, 2011). As capital requirements change over time, the trigger may neither be the same or fixed throughout the investment period. Additional capital requirements as the ones imposed by CRD4CRR may also be applied by the Bank of Portugal and give rise to a multi-trigger CoCo, creating extra risk for the investment. As conversion does not improve the Core Tier 1 ratio, the bank will be at/below minimum capital requirements upon conversion. If the regulator is perfectly strict, shareholders know that they (along with the government)

must be the ones recapitalizing the bank or be wiped-out straight away, in the event of conversion. In this case the disciplinary effect of default is still in place, meaning the bank may still be tempted to increase asset risk at this point, not only to avoid conversion but also enforced restructuring (Glasserman et. al, 2013). This indicates that the trigger should have been set higher, to avoid such risk-taking incentive near bankruptcy (Albul et al., 2010). Nevertheless, a higher trigger would make conversion almost inevitable (BCP's CT1 Ratio was 12,11%, as of June 2012), rendering proper management as useless (Himmelberg and Tsyplakov, 2012).

Governments CoCo sale option

The Portuguese government can sell the CoCo's but this will result in immediate conversion of the bond. This means that this CoCo also has characteristics of a straight convertible bond: if the government perceives that the proceeds of selling converted shares are higher than keeping the bond, it will sell it and force conversion, thus getting an upside. Furthermore, it means that the multiple equilibrium problem in both CoCo and equity prices (Sundaresan and Wang, 2010) will not take place because: CoCo's will never enter the open market as CoCo's but as shares; the government is not allowed to hedge its exposure. The government could sell the CoCo's in order to get budget funding earlier than waiting for the bank to call the CoCo or sell mandatorily converted shares. However, the sale could lead to the belief among investors that the bank was actually in trouble, putting at risk its stability and that of the remaining domestic banks, for which we assess such a move as unlikely.

Mandatory Conversion at Maturity

The CoCo's convert mandatorily at the end of the contract in case they are not called back until then. This can create bad incentives by removing the disciplinary effect

of default (Sundaresan and Wang, 2010), as the bank can never default on the CoCo. Since shareholders know they will not be wiped-out and forgo all controlling rights, they may relax their risk management policies allowing for asset volatility to increase (Koziol and Lawrenz, 2011). Furthermore, they know they are not obliged to call the whole CoCo back, and may have the luxury of letting a small part to convert, while still retaining most of the controlling rights and cash flow. By forcing principal repayment at the end, default discipline should force the bank to behave in order to secure refinancing for the total amount of the CoCo. In this case, if the company defaulted, the government would probably be one of the new shareholders due to the seniority of the CoCo - just above common equity – and could even appropriate value left by the wiped-out shareholders. In any case, the conversion terms of the structure give banks good reasons to call the bond back.

Conversion Terms

The conversion terms are in the form of discounted share price at conversion and adjustable number of shares, resulting in a full conversion fraction. The equity issue is at the discount of 35% over the volume weighted stock price average of 5 days before the announcement, implying that the conversion price is very likely to be lower than the stock price observed for that day. Therefore, a transfer of value from shareholders to CoCo holders is almost sure, being a feature appraised by academics for imposing risk management and proper governance, including issuing equity to avoid conversion and lead the firm to pursue more conservative capital structures (Himmelberg and Tsyplakov, 2012). However, there is the possibility that shareholders manipulate the market on their favour (as the government could not, even if it was legal) as the 5-day moving average may be too small (Calomiris and Herring, 2011), for which we would

have recommended the government to set a roof conversion price in order to secure a minimum of BCP shares upon conversion. In any case, due to the relatively diluted shareholder structure of the bank, the risk of market manipulation should not be significant. The severity of the conversion terms for the bank can be seen as a sign of the bargaining power of the government. If the bail-out had not been through CoCo's, the government would have nationalized the bank. Therefore it can enforce contract clauses that the bank would never accept otherwise. Due to the CoCo's conversion terms and size, there are reasons to believe that conversion discipline can be nearly as strong as default discipline, as of the issue date in case no CoCo's have been called. This is so because conversion could actually shift the bank's control over to the government due to the number of shares that the government would get in the event of conversion, even though former shareholders would still retain some voting rights. Exhibit 2C, shows that the required stock price at conversion for the current shareholders to retain control is quite high, both at the time of the issue and at the September 2012 equity issuance, compared to the current share price (Exhibit 2D) for various amounts of CoCo's. This latter equity issuance at a very discount price can also be seen as a way of limiting the likelihood of handing the control of the bank to the government, due to the high increase in the number of shares. From an investment point of view, the value the government is expected to get at conversion will depend on the of the share price when approaching conversion (whether it is expected or not, or manipulated) and on any further adjustments to accommodate for dilution. Since a 5-day average is very short, potential for market manipulation is very high. If shareholders incorporate dilution, the stock should be trading very low, meaning that the stock at the day of conversion could be even lower than the 5-day average, meaning that the

government would be making a loss on that day. The government may end up with a very high number of shares, meaning that even small moves on the stock price will lead to massive swings on the value of the government's position. However, given the very discounted price by which it acquires shares, there are still chances that the government can make a profit. A wise move could be to hold the shares instead of selling them right away, as any sale of a block of shares can depress the price heavily. For instance, if the government was able to sell all the shares at the exact market price with which the conversion price was calculated, then a massive revenue would be obtained: €1,5385 per € of book CoCo's (see Appendix 1) . Such optimism could justify the relatively low coupon rates. Still, if the government incurs in a loss, the social benefit of keeping the bank afloat can offset the possible loss due to conversion.

BCP CoCo Call Option

As we have mentioned, the banks also have the option to call the CoCo, by paying the par value of the bond plus any accrued interest that was already due but not yet paid. If the bank intends to do so, it is entitled to a flexible repayment schedule and may call the bond earlier if it wants to. This relieves some roll-over pressure as it would be too difficult to raise €3 billion at once, so the bank can exercise part of the call whenever it has capacity to do so, provided that conversion did not take place until then. Calling the bond not only cancels future coupons but also eliminates the possibility of having a value expropriating conversion and eliminates the upside potential for the government that we mentioned earlier. On the assessment on whether the bank will want to call the bond we have to consider what the P&L of calling the bond would be compared to the P&L of allowing dilution. Calling the bond implies that the bank must raise funds either by: issuing new equity (very difficult costly in these times), issuing

another CoCo (which would not avoid the problem of an eventual conversion, in case conversion took place at the same trigger level), issuing debt (which puts negative pressure on the Core Tier 1 ratio) or use excess cash/selling assets (putting at risk the ability for the company to generate cash-flows in the future). On the other hand, allowing conversion can result in heavy dilution and also a loss of control over the company by current shareholders.. On the July 25th 2012, BCP approved its recapitalization plan, which involved repaying €0,5 billion in 2014, €1 billion in 2015 and €1,5 billion in 2016. In this sense, we see that the bank as a clear intention of repaying the CoCo: allowing conversion is undesirable. In fact, such a decision is preferable for both sides: the bank does not want to have their shareholders diluted and having control shifted to the government and neither the government wants to have a diseased bank in its balance sheet, waiting to be recapitalized once again. Given the negative outlook of BCP, as we discussed in the previous section, raising funds to call the bond may be difficult, not to mention that the banks as other liabilities to roll-over. Selling assets can be a good strategy, disposing of risky assets and increase their Core Tier 1 ratio, even if future profitability is being put at stake. The sale of Piraeus can be seen as an example, even though the proceeds were not used to repay CoCo's. As for debt financing, unless the bank is able to generate profits, creditors may not lend such an amount of money, taking as well the remaining liabilities of the bank. Furthermore, refinancing the CoCo does not reduce Risk-Weighted Assets, creating limits for bond issues. The deferred tax asset agreements have changed the picture, as they allow for an increase in the Core Tier 1 ratio, which could generate confidence in the markets and let BCP refinance the CoCo's with new debt. As a last resort, the bank may decide to raise equity on its own if it perceives that such will result in lower dilution than letting the

government have shares. If current shareholders are the ones to pour in equity, they may also maintain their control of bank.

Payout Restrictions

As an additional covenant, the bank is not allowed to distribute dividends as long as there are CoCo's in its balance sheet. This is a positive point as the bank will strive to call the bond, pleasing shareholders by both avoiding dilutive conversion and paying out dividends.

Coupons (continued)

Due to the uncertainty regarding the bank's future, it is rather puzzling why the government issued these callable CoCo's at par, paying lower coupon rates than those demanded by the CDS curve at that time. In this sense, the government expected to make enough profit with the converted equity to compensate for the coupon cancelation, either due to calling or conversion. However, the Government will may be forced to pour in more money if it wants the bank to stay afloat as it will be at/below the minimum capital requirements by then, implying that this contract will only have value upon conversion if the government is in fact willing to eventually re-rescue the bank, either by issuing new equity or CoCo's of the current type. On the other hand, the government is also interested in the social well-being, meaning that rescuing the banks it rescued should generate overall social stability, offsetting the loss that may arise from the investment. In any case, it is known that the CDS curves had been falling until the approval of the contract in anticipation (Exhibit 2B) but, by then, no one could tell that yields would keep dropping as they did. Investors would eventually have asked for lower yields on the remaining debt in the anticipation of the contract, as CoCo's should reduce the probability of default and reduce straight debt yields (Himmelberg and

Tsyplakov, 2012). Assuming knowledge about this yield drop, then the decision of the coupon schedule by the government becomes reasonable, as the extra coupon could be simply seen as a compensation for equity risk and coupon cancelation. As of January 3rd 2014, the yields of CDS's on BCP's subordinated debt are almost half the coupon rates.

All in All

Overall, at inception the contract has both pros (high potential dilution, regulatory trigger, full conversion and payout restrictions) and cons (relatively low coupon rates, conversion price subject to market manipulation, mandatory conversion at the end). The call option, even though it results in coupon cancellation, relieves the government from conversion uncertainty and allows it to recover its investment sooner. In any case, the success of the contract as an investment depends not only on the bank's performance but also on the value of the stock at the case of conversion which, as we discussed, may not solely represent the future expectations for the bank but also include market manipulation. As a precautionary measure, we would have advised the government to establish a roof conversion price, in order to assure a minimum number of shares per € of CoCo investment. As a social investment, we consider the contract to be quite effective in terms of incentives, although one must be aware of the possibility of risk-seeking by the bank, which can actually increase its probability of default (Koziol and Lawrenz, 2011). In any case, the opportunity cost of this investment could be to put the supply of credit to the Portuguese economy at stake. That would reduce confidence in the Portuguese financial system and injure both the government's and the remaining banks' refinancing capabilities.

Section III – CoCo conversion and Provision Break-even

It is now clear that avoiding CoCo conversion is one of the top priorities of BCP. To do so, the bank must call whatever it cans of the bond until maturity, as any CoCo's left by then will convert.

To avoid conversion in the first place, the must increase its Core Tier 1 Equity and/or reduce its Risk-Weighted Assets and/or increase asset volatility, as a last resort measure. To increase Core Tier 1 Equity, the bank must either have profits or issue new equity into the market. By increasing profits we mean: expanding the operating margin (increasing interest margin and banking fees and reducing costs with rents and personnel), reducing provisions (increasing credit quality, renegotiating loans) and sell assets at premium (as a last resort measure, as it may put future profitability at stake). When issuing new equity, dilution will take place but it may also benefit former shareholders if conversion is otherwise likely. To reduce Risk-Weighted Assets (RWA), the bank must change its exposure to asset classes which have a lower risk weight. The bank could, for instance, reduce exposure in corporate bonds and increase it in government bonds. As we have discussed, since RWA is a qualitative measure, the bank could in principle increase asset volatility as a last effort to avoid conversion by reducing exposure in assets with low expected volatility and increase it in assets with high expected volatility, even within the same asset class: they would have the same weight.

The main problem of the bank has been the amount of provisions it has been forced to record (Exhibit 1B). As these depend mostly on the quality of past loans and on regulatory pressure to force provisioning of assets, the bank has relatively little power to avoid them in the short term. On the other hand, by increasing the quality of

loans (credit standards) and monitoring, the bank can diminish the impact of provisions in the near future. As a simple exercise, we calculated the break-even level of provisions per year the can record before conversion takes place. By assuming that Risk-Weighted Assets only decrease because of provisions, considering different growth rates for the operating margin and a tax-less environment, we got the graphs from Exhibits 2A and 2B, corresponding to the June 2012 and June 2013 starting points. Not only these break-even provisions are relatively low, while today we know the bank has exceeded their amount in 2013, having avoided conversion by diminishing Risk-Weighted Assets (see Exhibit 1B). In an optimistic way, calculated the new break-even provisions starting on June 2013, assuming the operating margin of June 2012 as a starting point (Exhibit 2C). Still, the bank does not get much more room to go around. In this way we can see that the bank must put effort to reducing Risk-Weighted Assets to avoid conversion. Given this scenario, calling back the CoCo's may be a difficult task as creditors may not believe in the banks solvability. As we mentioned, the deferred tax asset agreements may change the picture and are considered the reason why the stock price almost tripled. In any case, from Exhibit 1A, we see that the bank as actually been able to increase the Core Tier 1 Ratio in latest quarters.

Section IV – CoCo Evaluation Model

Metodology

In this section we will make our attempt at pricing the CoCo issued by the Portuguese Government to Banco Comercial Português (BCP) on June 29th 2012 and maturing on June 29th 2017. We will be building a structural model in the light of the Merton model (1974), as many other academics did. Our point will be to add some of contract features one at the time, in order to determine how they contribute to the overall price. Our interest will be in attributing a value to CoCo's and shareholder equity, for which we will ignore any other liabilities' value as deposits, senior, junior or other hybrid bonds. We will make use of Monte-Carlo simulation, where we will consider that the operating margin of the bank (interest margin, banking fees and commissions, financial services and non-interest operating costs), excluding CoCo coupon payments, follows a Geometric Brownian Motion:

$$\Delta M_t = M_{t-1} \times \left(r(\Delta t) + \sigma\varepsilon\sqrt{\Delta t}\right)$$

Where M_t is the operating margin at time t, ΔM_{t+1} is the change on the operating margin from $t-1$ to t, r is the expected annual growth rate of the operating margin and σ the annual standard deviation of operating margin growth rates, while ε is a random draw from the inverse standard normal distribution. We will be computing monthly steps, for which Δt corresponds to a month.

In this sense, we will be simulating the book value of assets (A) of the bank after which we will try to connect it with its market value. The bank's right side of the balance sheet will be composed of a senior bond (D) and a CoCo ($CoCo$) of the same maturity (T), as well as shareholders equity (E). Since we are assuming there is a single

senior bond in the balance sheet, we are implicitly considering that deposits do not change, regardless of the company's decisions and the macro environment, while also excluding potential roll-over costs (considered as essential by Glasserman et al. (2013)). In addition, when the bank calls the CoCo back, it will be refinancing it with senior straight bonds (L), which will gradually replace the CoCo's on the balance sheet. The bank will not be allowed to pay dividends until period T, even if the entire CoCo's have been called until then, for simplicity. We will exclude any taxes from the picture.

We will consider that the minimum capital requirements will not change until the maturity contract, so therefore the CoCo will trigger in case the Core Tier 1 ratio level is verified at or below the trigger ($CT1R^*$). Conversion can happen at any point t, which is the same as assuming that the regulator has oversight of the bank's accounts the whole time, taking action as soon as the trigger level is hit. The regulator is thus excluding any other parameters to determine whether more equity is required or not. The Core Tier 1 ratio is defined as the amount of Core Tier 1 equity to Risk-Weighted Assets (RWA_t). For simplicity, we will assume that all the shareholders equity (E) is Core Tier 1 equity, while we also know that BCP's CoCo's are also considered as Core Tier 1 Equity as of the issue date. Therefore, the difference between assets and the senior bond plus any CoCo's that were already called will yield the total Core Tier 1 Equity ($CT1E_t$). The company will be allowed to sell assets at premium, in order to generate extra gains. Risk-weighted Assets will be a fraction (f) of total assets minus the book value of any assets sold. In this sense, we are considering that the bank will always sell assets whose risk-weight is equal to 1 (the riskiest).

At any time t, the time schedule will be the following: $\boldsymbol{Step\ 1}$, the company incorporates results from the operating margin (M_t), provisions (P), CoCo coupons

(cc_t) and refinancing coupons (rc_t). ***Step* 2**, it will decide whether to sell assets (AS_t) or not**. *Step* 3**, it will consider whether it will ask for a CoCo refinancing loan (L_t) or not. ***Step* 4**, the company will add any accrued interests paid (ai_t) to the P&L. ***Step* 5**, the leftover CoCo's ($CoCo - \sum_{t=0}^{t} L_t$) may convert or not. ***Step* 6**, the company may default or not. Throughout the work, any variable with exponential Si (as A_t^{Si}) will mean the value of the variable after completion of step i, where $i^{\mathbb{N}} \in [1,6]$.

As we have discussed, bank provisions have been the biggest challenge in the firm's P&L. Future provisions depend mostly on: the amount of overvalued assets left in the bank's balance sheet, the strictness of the regulator when forcing the banks to declare such losses and the future macroeconomic outlook which will influence the expected quality of current and future loans. To avoid major assumptions, we will simply assume the bank is forced to declare an exogenous amount of provisions (P) in each period.

CoCo coupons (cc_t) depend on the amount of CoCo's outstanding in the previous period ($CoCo - \sum_{t=1}^{t} L_{t-1}$) and the coupon rate (cr_t) due. In our model, these will always be paid in case the CoCo did not convert in any of the previous periods. Then, CoCo coupons can be defined as:

$$cc_t = \left(\left(CoCo - \sum_{t=1}^{t} L_{t-1} \right) \times cr_t \middle| \left(\sum_{t=1}^{t} \max(\, CT1R^{*} - CT1R_{t-1}^{S4}; 0\,) \right) = 0 \right)$$

The bank will have the option to sell assets (AS_t), from a stock of sellable assets (SA) whenever its Core Tier 1 ratio in $t-1$ is below a certain threshold $CT1R^{AS}$ and will do so until the gains of the sale increase the value of assets to the point where $CT1R_t^{S2} = CT1R^{AS}$. We must not forget that the company cannot sell more assets than those it has to dispose, even if the current ratio requires more than the available. The gain will

depend on the price-to-book of these assets ($P^{AS}/B^{AS} > 1$), which will be fixed over time. The amount of asset sales is thus defined as:

$$AS_t = \left(min\left[\frac{A_t^{S1}(1 - CT1R^{AS} f) - D - \sum_{t=1}^{t} L_{t-1} - CT1R^{AS} \sum_{t=1}^{t} AS_{t-1}}{1 + \frac{P^{AS}}{B^{AS}}(CT1R^{AS} f - 1) - CT1R^{AS}(f - 1)} \; ; \; SA - \sum_{t=1}^{t} AS_{t-1} \right] \middle| \begin{cases} CT1R_t^{S1} < CT1R^{AS} \\ SA > \sum_{t=1}^{t} AS_{t-1} \end{cases} \right)$$

If $CT1R_t^{S2}$ is higher than a threshold $CT1R^{CA}$, the bank will be able to refinance part of the CoCo by issuing a straight bond (L_t) up until $CT1R_t^{S3} = CT1R^{CA}$. The reasoning is that creditors take the Core Tier 1 ratio as a standard creditworthiness measure and so, after a certain ratio level, they are willing to loan money to the bank until the ratio is re-established. With this loan, the bank will only repay CoCo's, while the accrued interest will go directly to the P&L. By definition, calling the bond is conditional on non-conversion in any previous period. We must not forget that by repaying CoCo's and paying accrued interests, the bank is decreasing its Core Tier 1 equity, so the loan amount should also reflect this decrease, as we consider that the bank fully convinces the lenders about the use of the loan proceeds. Depending on the amount of CoCo's left to call, BCP may not need to exhaust its loan capacity, so:

$$L_t = \left(min\left[\frac{A_t^{S2}(1 - CT1R^{CA} f) - D - \sum_{t=1}^{t} L_{t-1} - CT1R^{CA} \sum_{t=1}^{t} AS_{t-1}}{(1 + ar_t)} \; ; \; CoCo - \sum_{t=1}^{t} L_{t-1} \right] \middle| \begin{matrix} CT1R_t^{S2} > CT1R^{CA} \\ CoCo > \sum_{t=1}^{t} L_{t-1} \\ \left(\sum_{t=1}^{t} \max(\, CT1R^{*} - CT1R_{t-1}^{S4}; 0\,) \right) = 0 \end{matrix} \right)$$

where ar_t is the accrued rate (linear in between coupon payment dates). Accrued interest (ai_t) will depend on the accrued rate and the amount of CoCo's called in period t, measured by the size of the loan:

$$ai_t = L_t \times ar_t$$

We will admit that the loan is like straight bond, whose coupon rates are equal to the CoCo's. For simplicity, we will say that the overall coupon payment schedule does not change, and it will work as if no CoCo's had been called. Once again, rc_t are paid depending on the sum of total CoCo's called until $t-1$:

$$rc_t = \sum_{t=1}^{t} L_{t-1} \times cr_t$$

So far, we know that:

$$A_t^{S1} = A_{t-1}^{S6} + M_t - P - cc_t - rc_t$$

$$A_t^{S2} = A_t^{S3} = A_t^{S1} + AS_t\left(\frac{P^{AS}}{B^{AS}} - 1\right)$$

$$A_t^{S4} = A_t^{S3} + ai_t$$

$$E_t^{Si} = A_t^{Si} - D - \sum_{t=0}^{t} L_t - \left(CoCo - \sum_{t=0}^{t} L_t\right) \quad , i^{\mathbb{N}} \in [1,4]$$

$$RWA_t^{Si} = fA_t^{Si} - \sum_{t=0}^{t} AS_t \quad , i^{\mathbb{N}} \in [1,4]$$

$$CT1R_t^{Si} = \frac{A_t^{Si} - D - \sum_{t=0}^{t} L_t}{RWA_t^{Si}} \quad , i^{\mathbb{N}} \in [1,4]$$

Recall that all these variables are expressed in book value. If we want to attribute a market value to the CoCo's and equity, we must establish a connection between the book and the market value of the two. In our model, we only need to need to define the price-to-book of equity (P^E/B^E), which we will assume to be fixed over time, as Glasserman et al. (2013) and Himmelberg and Tsyplakov (2012) did. Although unconverted CoCo's will always be priced at book, the same may not be true for the remaining liabilities and so, by establishing a price-to-book of equity, we are circling around the problem of determining their value.

Concerning Step 5, in case $CT1R_t^{S4}$ is lower than $CT1R^*$, all the uncalled CoCo's plus any accrued interests will convert to equity – time c. We will call these interests as convertible interests (ci_t), which are defined as:

$$ci_c = \left(\left(CoCo - \sum_{t=0}^{c} L_t \right) \times ar_c \middle| \left(\sum_{t=0}^{t} \max(CT1R^* - CT1R_t^{S4}; 0) \right) > 0 \right)$$

The number of shares issued upon conversion of the CoCo will depend on the 5-days-before-the-announcement weighted average of the stock price. From our model, we can extract the stock price exactly before conversion by using the price-to-book of equity. However, as we have discussed, expectations matter when determining that price especially because, after conversion, the company becomes less leveraged. In reality, we know that, regardless of the number of shares issued, their total book value will stay the same, for which the share price should adjust according to the new total number of shares. In any case, we will exclude the market manipulation hypothesis from our model and will focus on two possibilities: unexpected conversion versus expected conversion. In the first case, shareholders are caught by surprise and, therefore, there is no share price adjustment immediately before conversion. However, the share price will jump afterwards in order to accommodate for the new number of shares. Therefore, the correspondent share price (SP_c^{UE}), depending on the number of former shares (ss):

$$SP_c^{UE} = \frac{E_c^{S4} \frac{P^E}{B^E}}{ss}$$

In the second case, shareholders adjust the stock price in order to accommodate for the new number of shares, which is dependent on that same price they establish. They also know how much equity will be left after conversion. Since the share price SP_c^E must not jump after conversion:

$$SP_c^E = \frac{(A_c^{S4} - D - \sum_{t=0}^{c} L_t)\frac{P^E}{B^E}}{ss + \frac{(CoCo - \sum_{t=0}^{c} L_t)}{SP_c^E \gamma} + \frac{ci_c}{SP_c^E \eta}} \equiv SP_c^E$$

$$= \frac{(A_c^{S4} - D - \sum_{t=0}^{c} L_t)\frac{P^E}{B^E} - \frac{(CoCo - \sum_{t=0}^{c} L_t)}{\gamma} - \frac{ci_c}{\eta}}{ss}$$

where γ and η are the discount ($\gamma, \eta < 1$), par ($\gamma, \eta = 1$) or premium ($\gamma, \eta > 1$) with which CoCo shares and convertible interest shares are issued respectively, in comparison with the share price at the time of conversion. From here, one can see that, depending on the value of assets, total loans/uncalled CoCo's, convertible interests, γ and η, the equation can go negative (shareholders would want to be paid to hold shares), so we will bound SP_c^E at zero, due to the non-negativity condition of stock prices:

$$SP_c^E = max\left(\frac{(A_c^{S4} - D - \sum_{t=0}^{c} L_t)\frac{P^E}{B^E} - \frac{(CoCo - \sum_{t=0}^{c} L_t)}{\gamma} - \frac{ci_c}{\eta}}{ss} \quad ; \quad 0\right)$$

If $SP_c^E = 0$, CoCo holders get all the equity since the number of issued shares is infinite.

Depending on the stock price at that time (SP_c), the number of shares issued to CoCo holders (cs_c) is thus:

$$cs_c = \begin{cases} \frac{CoCo - \sum_{t=0}^{c} L_t}{SP_c \gamma} + \frac{ci_c}{SP_c \eta} & , SP_c > 0 \\ \infty & , SP_c = 0 \end{cases}$$

Whose book value is $CoCo - \sum_{t=0}^{c} L_t + ci_c$ and whose market value after conversion at t equals:

$$\begin{cases} \frac{cs_c}{ss + cs_c}(A_c^{S4} - D - \sum_{t=0}^{c} L_t)\frac{P^E}{B^E} & , SP_c > 0 \\ (A_c^{S4} - D - \sum_{t=0}^{c} L_t)\frac{P^E}{B^E} & , SP_c = 0 \end{cases}$$

and former shareholder equity is all that is left from the CoCo equity.

Summarizing book values from step 5:

$$A_t^{S5} = A_t^{S4}$$

$$E_t^{S5} = \begin{cases} A_t^{S5} - D - \sum_{t=0}^{t} L_t\,, & CT1R_t^{S4} \leq CT1R^* \\ E_t^{S4}, & CT1R_t^{S4} > CT1R^* \end{cases}$$

$$RWA_t^{S5} = fA_t^{S5} - \sum_{t=0}^{t} AS_t$$

$$CT1R_t^{S5} = \begin{cases} \dfrac{A_t^{S5} - D - \sum_{t=0}^{t} L_t + ci_t}{RWA_t^{S5}}, & CT1R_t^{S4} \leq CT1R^* \\ CT1R_t^{S4}, & CT1R_t^{S4} > CT1R^* \end{cases}$$

Now we will consider the final step which is that in which the company defaults/requires external restructuring. We will consider that in this scenario, equity holders are wiped-out: anyone willing to recapitalize the bank at this point will require the full control. In our model, default can happen in 3 and-or ways: shareholder equity becomes 0 or negative; the Core Tier 1 ratio of the company goes below a certain level $CT1R^W$; the Core Tier 1 ratio of the company stays below the minimum requirements $CT1R^R$ for more than d periods in a row. While the first is based on accounting laws, the second and third conditions are modulations of how the regulator could determine that the firm requires further restructuring, assuming he may not be strict. The "regulatory default" scenario (Z) can thus be defined as:

$$Z \equiv \begin{cases} CT1R_t^{S5} \leq CT1R^W \\ \left(\sum_{d=0}^{d} \max\left(CT1R_{t-d}^{S5} - CT1R^R; 0 \right) \right) = 0 \end{cases}$$

Formally, the market value of equity at t, after step 6 can then be defined as:

$$E_t^{S6}\frac{P^E}{B^E} = \begin{cases} 0, & E_t^{S5} \leq 0 \ \vee \mathrm{Z} \\ E_t^{S5}\frac{P^E}{B^E}, & Otherwise \end{cases}$$

All the remaining book values remain the same, as we assume the company will not be liquidated and the new owners will get all the assets. We are leaving out the case in which bankruptcy can occur before conversion. If it took place, CoCo holders, as the second to last in the seniority line, would eventually be forced to become the new shareholders and could eventually appropriate value left by the former wiped-out owners but given the uncertainty of payoffs in this scenario, we will consider a wipe-out of CoCo holders as well. If the company is restructured, all future payoffs to equity are thus zero while the recovery rate of CoCo holders will also be zero, whether bankruptcy takes place after conversion or not.

At maturity T, any CoCo's left will convert, conditional on non-conversion before, where the conversion price has the same characteristics as if $c < T$. Finally we will consider that the government will hold converted shares until the maturity T and be able to sell them at the prevailing stock price, regardless of the number of converted shares against the total.

At last, the final values of CoCo's and former shareholder equity are therefore:

$$CoCo\ Value = \sum_{t=0}^{T}\frac{cc_t + L_t + ai_t}{(1+r_t^D)^t} + \left(\frac{cs_c}{ss+cs_c}(A_T^{S4} - D - \sum_{t=0}^{c} L_t)\frac{P^E}{B^E}\middle|\begin{Bmatrix}\exists c \leq T \\ not\ Z\end{Bmatrix}\right)\Big/(1+r_0^E)^T$$

$$Equity\ Value = \frac{\left(\left((A_T^{S4} - D - \sum_{t=0}^{T} L_t)\frac{P^E}{B^E}\middle|\begin{Bmatrix}\nexists c \leq T \\ not\ Z\end{Bmatrix}\right) + \left(\frac{ss}{ss+cs_c}(A_T^{S4} - D - \sum_{t=0}^{c} L_t)\frac{P^E}{B^E}\middle|\begin{Bmatrix}\exists c \leq T \\ not\ Z\end{Bmatrix}\right)\right)}{(1+r_0^E)^T}$$

where r_t^D (per unit of time) is the yield taken from the term structure of interest rates of BCP's subordinated debt for time t and r_0^E(per unit of time) is the cost of equity of the company at the time of the issue.

Using the model – June 29th 2012

Since BCP's CoCo's are not traded on the market, there is no way to backtest the predictive power of the model. In any case, we will use it as a tool to measure the sensitivity of CoCo's and equity prices to some of its parameters.

We will start by pricing the CoCo at the issue date – June 29th 2012. Starting values for assets (A) and senior debt (D) are taken from the financial statements of June 30th 2012 which, as usual, were not available on that day. On the other hand, since they are close to the issue date, these values should not differ much from those in the financial statements. The value of f will be the percentage of Risk-Weighted Assets to Assets in these statements. r and σ will be estimated from the operating margin, year-ending in each quarter, from 2009 until 2012. P_t^E/B_t^Ewill be the average of the price-to-book of equity from 1Q 2009 until 2Q 2012, at the end of the day the corresponding financial statements were made public.

CoCo notional, coupon rates, γ and η will be taken from Diário da República (**Despacho n.º 8840-B/2012)**

. $CT1R^*$ and $CT1R^R$ will be the value defined by the Bank of Portugal. The various r_t^D will be taken the CDS curve for subordinated bonds on the day of the issue (Exhibit 2B) while we will take r_t^E as given from Bloomberg. As for $CT1R^{AS}$, $CT1R^{CA}$, $CT1R^W$, P, d and SA will be defined at levels that we consider to be reasonable.

For the inputs, see table Exhibit 4A and for the outputs, see table Exhibit 4B. From the output table, we see that calling the bond is an optimal choice for equity

holders, according to our model, existing an upside potential against the value of the stock on that day (Exhibit 2D). However, if shareholders expect conversion calling the bond is not optimal for the government, from a perspective of value.

Sensitivity Analysis

We will now apply sensitivity analysis to some of the parameters in our model, having (Model 1- Exhibit 4A) as our base case in June 29th 2012– model 1, in our output table. From Exhibit C, we see that the combined value of the CoCo and equity increase linearly with the Price-to-Book to Equity that we establish. However, the CoCo value stabilizes after a point, as the increase in the conversion price also leads to a smaller number of CoCo shares, upon conversion. Exhibit 4D shows that the value of the CoCo is the highest, the sooner it is called, while equity value is maximized when the bond is called when the company has a Core Tier 1 ratio shortly above the trigger level. From the graph, one could say that equity holders will call the bond sooner than we have considered – we will explore further hypothesis. As provisions go up, the value of both CoCo's and equity go down, as the company is increasingly likely to be restructured by the regulator (Exhibit 4E). This graph shows that CoCo equity becomes the highest soon above the no provision level: too low provisions allow for the call while the company is restructured at high provisions, swallowing the value of CoCo Equity. The volatility of the operating margin (Exhibit 4F) affects mainly the distribution of value between Equity holders and CoCo holders: at low levels, given that the starting operating margin value is lower than the provisions in our base model, the bond will CoCo is likely to convert; as volatility increases, the shareholders have a higher chance of calling the bond and enjoy high payoffs. From this graph, we see that equity holders maximize the value of the firm by increasing volatility as, within our

model, they do not face roll-over discipline. Surprisingly, the CoCo trigger level affects the value of equity very little (Exhibit 4G), which slowly decreases as the trigger increases. Whit the exception for very low provisions, what is common to all the graphs is that the value of the CoCo never reaches the par of €3 billion. Our model thus states that the Portuguese Government overpaid for the CoCo's at the inception of the contract. However, the reduction on yields that took place afterwards should increase its value past our estimations. In any case, further sensitivity analysiswith multiple inputs should provide better insights on the sensitivity of CoCo and Equity value to parameters.

Deficiencies of the model

We have reasons to believe that the model may not be well specified.

First of all, we have left out some of the contract clauses, as we considered they were of little importance: the bank will always pay coupons in shares; coupons are paid even if it probably leads to conversion in the next period; the government will never trigger conversion by selling the CoCo's.

The first problem of our model is its high parameterization. Some of the thresholds are also difficult to estimate as they depend on the bank's internal management decisions (asset sale trigger and volume), the market perception and asymmetry of information (refinance trigger, Price-to-Book) and the regulatory strictness (provisions, default triggers). The consequence is that the value of CoCo's and equity is likely to be model dependent and very sensitive to inputs. Furthermore, we decided to let very important variables to be fixed over time for simplicity, even though they should change with the company's performance and future expectations: price-to-book of equity, provisions, operating margin returns and its volatility. Selling assets

should also influence future expected returns and volatility but we also have left out this effect.

The simplification of the debt structure of the company may be quite decisive for the outcomes of the model. As we are assuming a single long maturity bond, discipline of roll-over is left out and so are any potential deposit withdrawals that could occur due to the perception that the company is close to bankruptcy or because competitors offer better risk/return deals. Furthermore, we did not give the bank the chance to issue equity as an attempt to avoid conversion or refinance CoCo's. To do so, one could follow the idea of Glasserman et al. (2013) and introduce another default barrier were shareholders would decide whether pouring in more equity is better than abandoning the firm or not (endogenous default), in each point in time.

Fixing the price-to-book has thus additional consequences related to the capital structure of the firm, which we assume that changes only as a consequence of CoCo refinancing. In reality, if the company was able to repay the CoCo's, it would not allow the Core Tier 1 ratio to growth indefinitely (holding too much excess reserves) and would rather increase leverage to take advantage of its extra debt capacity. On the other hand, the bank could distribute dividends to shareholders, but we left out this scenario. In any case, given the parameters with choose for our model, these scenarios are unlikely and the bank would be struggling to repay the CoCo's in most of the paths.

We have also limited the bank's ability to reduce risk-weighted assets. By assuming these are a fixed percentage of assets, we are saying that the bank is reinvesting (disinvesting) any profits (losses) in assets whose risk-weight is the average of the company, which may not be true: the volatility of operating margin returns should not be constant. If the company accumulated cash, for instance, the risk of its assets

would not go up as cash is riskless. Additionally, reducing risk by selling assets is not the company's only option, as it may have the ability to shift the risk of their asset portfolio to safer allocations (on their trading portfolios for instance), increasing the credit lending standards for new loans, and monitoring the companies to which they have lent money. In this way, the firm could increase the Core Tier 1 ratio further and be able refinance the CoCo's more easily. Therefore, assuming a constant volatility for the operating margin returns is not the best option, even though it avoids more complex assumptions. What we see today is the bank was actually able to reduce Risk-Weighted assets a lot more than our model could predict, in comparison to the reductions of the amount of book assets.

Excluding taxes from the picture may have also been a bad assumption. Its inclusion would smooth the asset process as the company would pay taxes on good times and have tax benefits bad past times in the form of carry-forwards. Additionally, given the Deferred Tax Asset agreements we mentioned earlier, the company would be able to increase its Core Tier 1 ratio and eventually have a chance to call more CoCo's than our model predicts it would.

All in all, the model exhibits decisive problems. These may be one of the reasons why the model cannot explain properly the market capitalization jump of the company, after the equity issue of October 2012. Its assumptions are also related to the fact the BCP was actually in distress at the time of the issue of the CoCo. Therefore, even if the model worked well, it would not be suitable to value CoCo's issued by healthy banks. In any case, the model sheds some light on the magnitude of the provision problem for BCP and provides an insight on the difficulties to repay the bond plus the consequences of failing to do so, for current shareholders.

Section V – Conclusion

The Contingent Convertible debt is a bond that converts to equity, in case a certain trigger variable hits a pre-established level. It has been appraised as an incentive tool to impose proper risk management and corporate governance on bank managers. On the other hand, there are also concerns that the bond may lead the issuer to increase asset risk as a rational decision to increase the value of equity, when conversion is very likely.

The Portuguese Government lent Banco Comercial Português (BCP) €3 billion in contingent capital. We consider that the contract can be quite effective in terms of incentives due to the characteristics of its conversion terms. However, there is a chance that the Government loses money with it due to market manipulation. In any case, rescuing the bank should socially better than letting it go bankrupt meaning that the overall social well benefit should compensate any potential loss on the investment.

Provisions have been the biggest problem that BCP has been facing in the recent years, causing doubts on whether the bank will be able to call the bond and avoid losing control of the firm to the government.

We designed a simple structural model in order to value the contract as of the issue date, June 29th 2012. Our findings are that, for a wide range of parameters, the government overpaid for the contract, at inception. Additionally, the CoCo value tends to be higher, the sooner it is called. However, given its simplifications, we have doubts on the quality of the model as a tool to evaluate other similar Contingent Convertibles issued by firms other than BCP.

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Exhibits

Summary of the main Balance Sheet Items							
	1Q 2012	2Q 2012	3Q 2012	4Q 2012	1Q 2013	2Q 2013	3Q 2013
Assets	92029	92999	89274	89744	89474	83944	83121
Debt	87469	86053	82442	82744	82606	77527	76745
CoCo's	0	3000	3000	3000	3000	3000	3000
Equity	4560	3946	3832	4000	3868	3417	3376
Core Tier 1 Capital	5261	6732	6527	6606	6489	6094	6186
RWA	57188	55640	54847	53271	53625	48755	48711
Core Tier 1 Ratio	9,2	12,1	11,9	12,4	12,1	12,5	12,7

Exhibit 1A

P&L rubrics, calculated year-ending on each quarter							
	1Q 2012	2Q 2012	3Q 2012	4Q 2012	1Q 2013	2Q 2013	3Q 2013
Operating Margin	769	986	621	690	879	572	739
Provisions	-2201	-2682	-2647	-2037	-1996	-2037	-1998
P&L	-991	-1422	-1665	-1137	-946	-677	-527

Exhibit 1B

Full Name	Instrumentos de Capital Core Tier 1
Issue Size	EUR 3.000.000.000
Issue Date	June 29th, 2012
Subordination	Core Tier 1 Equity
Maturity	5 years
Coupon Payments	8,5% - 1y 8,75% - 2y 9% - 3y 9,5% - 4y 10% - 5y
- Periodiocity	Semi-annual
- Payment Type	Nominal or by issuing shares: $\#Shares = \frac{Coupon}{S(5dMA)\times 95\%}$
The Trigger	Accounting and Regulatory
- Accounting	Minimum Capital Requirements defined by the Bank of Portugal
Principal Conversion Price	$S(5dMA) \times 65\%$
Mandatory Conversion	The instruments are converted at maturity, at the Conversion Price.
Call Feature	The bank is allowed to buy back the instruments in case it is able to maintain capital above the minimum requirements, after the call.
S(5dMA)	Volume Weighted Share Price, 5 days prior to the day conversion/payment in shares is announced

Exhibit 2A

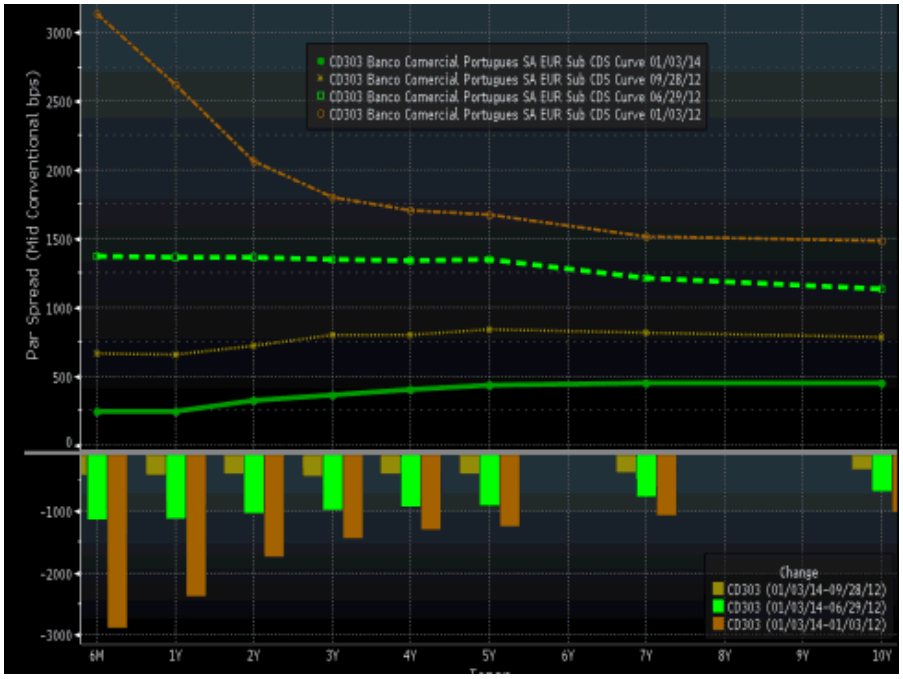


Exhibit 2B

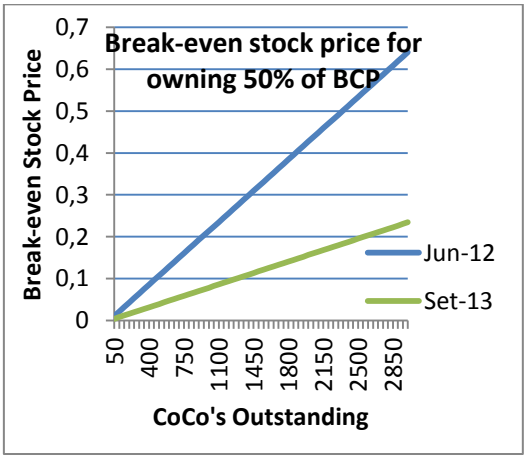


Exhibit 2C

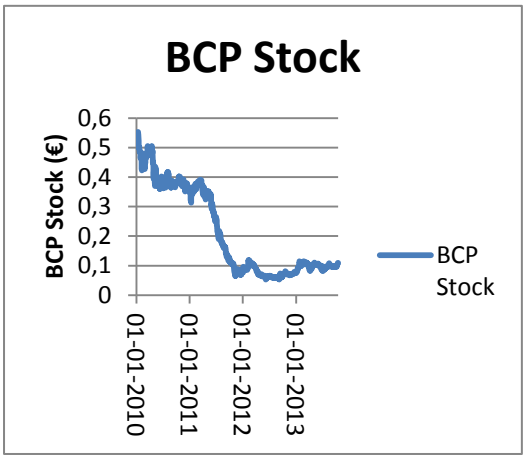


Exhibit 2D

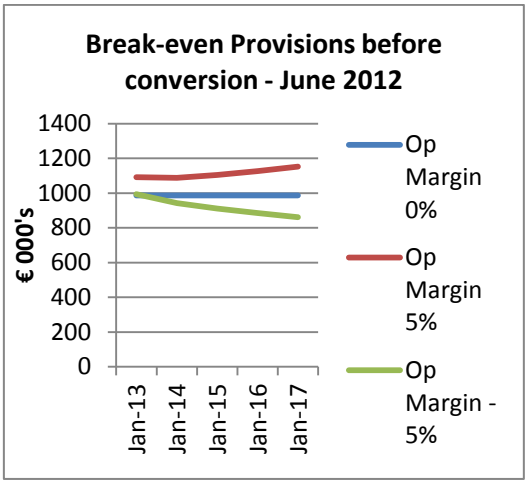


Exhibit 3A

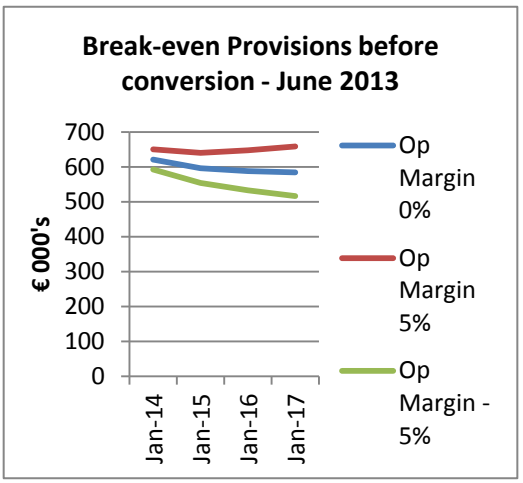


Exhibit 3B

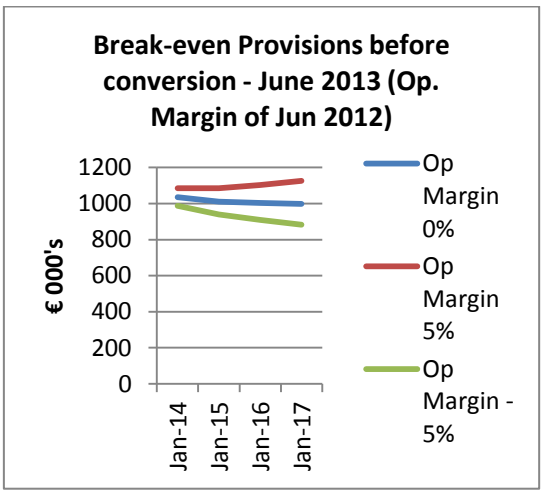


Exhibit 3C

Model Inputs			
A_0	92999	$CT1R^*$	10%
D_0	86053	$CT1R^{CA}$	13%
$CoCo_0$	3000	$CT1R^{AS}$	10,5%
M_0	82,08	$CT1R^R$	10%
P	83,33	$CT1R^W$	6%
SA	2000	d	6
ss	7207	P^E/B^E	0,586
r_E	14,99%	P^{AS}/B^{AS}	1,2
r	4,9%	γ	0,65
σ	40,23%	η	0,95
f	0,598		

Exhibit 4A

Model Outputs (€ 000, except the stock price)								
Model	ToTal CoCo	CoCo Coupons	CoCo Call	CoCo Equity	Stock Price	Call	Expected Conversion	Asset Sale
1	1987	789	371	827	0,09	Yes	Yes	Yes
2	1737	716	373	648	0,09	Yes	Yes	No
3	1754	789	371	595	0,13	Yes	No	Yes
4	1549	716	373	460	0,12	Yes	No	No
5	2077	849	0	1228	0,03	No	Yes	Yes
6	1829	777	0	1052	0,03	No	Yes	No
7	1712	849	0	863	0,09	No	No	Yes
8	1507	777	0	730	0,08	No	No	No

Exhibit 4B

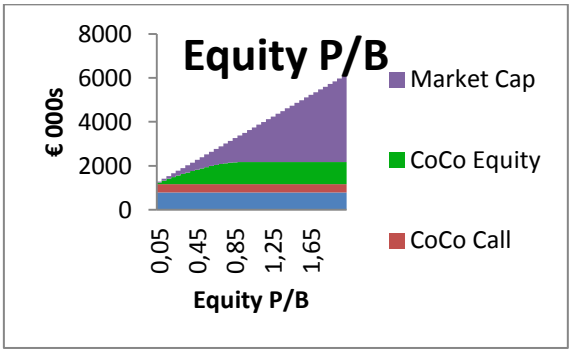
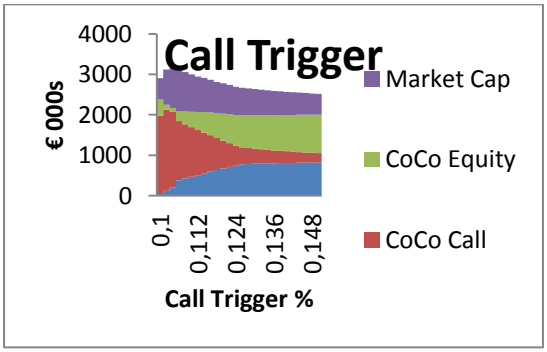


Exhibit 4C



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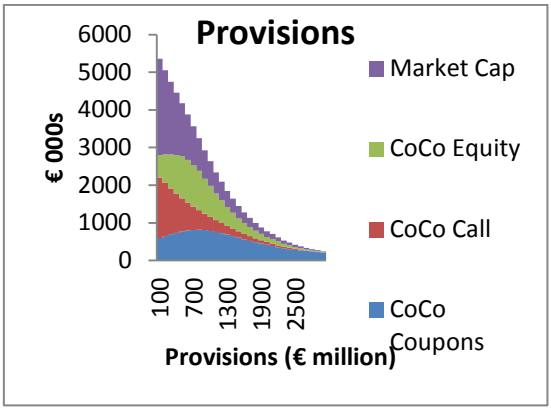

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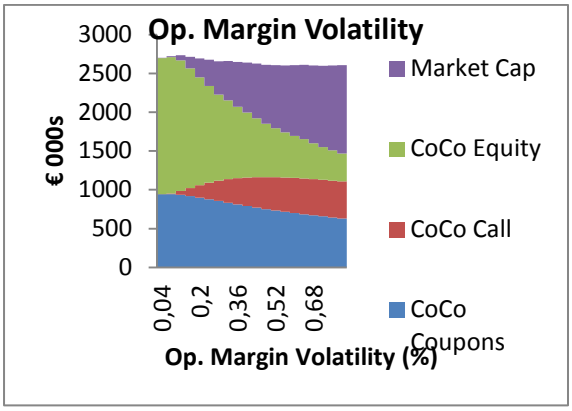

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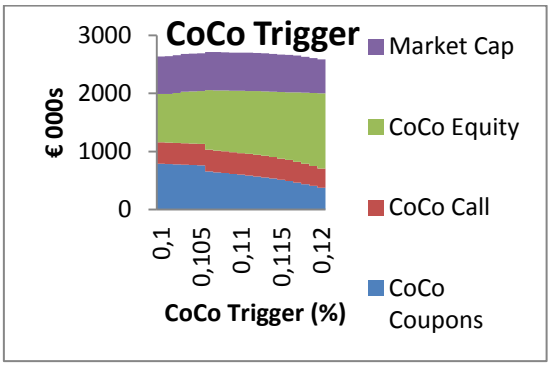

Exhibit 4G

Appendixes

Appendix 1:

CoCo's – description and design

The term "contingent convertible" (CoCo) bond is attributed to debt contracts in which either a part or the total principal is written down and converted into equity, when a variable or set of variables in the contract (the stock price of the issuer or its Core Tier 1 ratio, for example) hit a certain trigger level. CoCo's can therefore be seen as a type of a derivative contract, since conversion is determined by the value of another underlying variable. CoCo's can be subdivided into two main groups, depending on what happens when conversion is triggered: convertible CoCo's (as the Llyods Banking Group's *Enhanced Capital Notes*) in which the new book equity will take the form of new shares to be issued to these bond holders, resulting in dilution of former shareholders; pure write-down CoCo's (as the Rabobank's *Senior Contingent Notes*) in which the new book equity is attributed to the former shareholders and so there is no dilution. Throughout our work, we will be focusing on the CoCo's of the first type as they fit the contract established between the Portuguese Government and Banco Comercial Português on June 29th 2012, as a part of the latter's recapitalization plan.

The main difference between a straight convertible bond and a CoCo lies on the conversion feature itself: in the former, conversion is generally an option attributed to the holder, who will use it in a profit maximizing context; in the latter, conversion is mandatory once the trigger level is hit, regardless of the intentions of both the issuer and the holder to convert the bond or not (Sundaresan and Wang, 2010).

Although this type of securities had been used already in the 1990's by non-financial corporations (Culp, 2009), Flannery (2005) firstly presented this security in 2005 for use in the banking system, under the name of "reverse convertible bonds".

Most of the authors we will be citing from now on, have agreed on the benefits of the CoCo bond as a way to automatically recapitalize a bank when it is facing lack of capital. The goal would be to choose a trigger level that reflects this state, during which the access to capital markets is also likely restricted (Spiegeleer and Schoutens,). In this sense, CoCo's can also be seen as a "backstop for unforeseen market events" (McDonald, 2010). Recapitalization is translated not only in the write-down of the debt part but also in the new equity added to the capital structure. Conversion additionally reduces interest margin pressure and eases debt roll-over pressure. At that point, as the firm's financial position improves, markets become more

optimistic about the bank and the firm will have easier access to external financing. It is worth noting that conversion will force investors themselves (the CoCo holders) to recapitalize the bank in the first place – bail-in – as opposed to having the firm bailed-out by taxpayers, making the instrument appealing to regulators. Himmelberg and Tsyplakov (2012) further defend that CoCo's should always be present in a bank's capital structure (if it converts, new ones must be issued) to force bail-in's as the rule before any bail-out's, as bail-out expectations reduce default discipline (Calomiris and Herring (2011). In any case, a CoCo is not an insurance contract as the cash inflow takes place at the time of the issue and so conversion does not result in any monetary transfer between the issuer and the holder (Culp, 2009).

For banks, CoCo's can also be an alternative to issuing straight equity as they provide a tax shield (Albul et al., 2010) as long as the CoCo's are yet to convert. This is opposed to the debt overhang framework, where issuing equity creates value for bondholders. Additionally, as the CoCo's convert to equity in the bad scenario, issuing CoCo's to replace straight debt reduces the bank's probability of default, decreasing the cost of debt and thus the cost of equity (Himmelberg and Tsyplakov, 2012). Furthermore, issuing CoCo's increases the debt capacity of a firm, allowing for more leverage and potential for increasing the value of the company (Koziol and Lawrenz, 2011). In this sense, banks may be interested in issuing these instruments free-willingly. Himmelberg and Tsyplakov (2012) also argued that may extract extra potential from the CoCo's by issuing a combination between CoCo's and straight equity. Glasserman et. Al (2013) states that issuing equity in the presence of a CoCo increases shareholder value when the triggering is near, as it renders conversion as less likely.

Dilutive conversion is the main reason why, on the other hand, a firm may not want to issue CoCo's by themselves. Depending on the number of new shares and the amount of written-down debt, there may be a transference of value between equity holders and CoCo holders upon conversion, providing the contract with a unique incentive driving scheme. From a regulatory point of view, properly designed CoCo's can be used to force the issuer to: measure, manage and mitigate risk exposures properly (the type of loans, asset liquidity, portfolio exposures); analyse investment prospects carefully, taking into account the long-run profitability of the firm (higher credit quality standards for the borrowers, careful portfolio investments); issue equity pre-emptively, if necessary (Calomiris and Herring, 2011). This is attained not only by imposing dilutive CoCo's in a bank's capital structure, but also by ensuring that conversion will result in a transfer of value from shareholders to CoCo holders, making conversion as undesirable as possible for the firm (Glasserman et. al, 2013). This should force bank managers to do whatever they can to avoid it. Calomiris and Herring (2011) argue that even small CoCo tranches of this sort should be sufficient to accomplish this. CoCo's are

thus being increasingly regarded as a security which can mitigate the probability of a financial crisis to occur and that can promote financial stability and banking ethics.

Previously, firms would benefit from understating their risks by enjoy higher ratings and thus lower debt costs, while managers' bonuses were tied to short term profits (Calomiris and Herring, 2011). Now, the CoCo's objective is to put proper risk management back in the front line of the profit maximizing condition. A CoCo designed in this spirit should be also harmful for any bank's short-term profits. However, the potential for long-run benefits of financial stability should foster confidence and resolve in an overall social benefit and sustainable profits for banks themselves.

We will now decompose the CoCo in its main parameters: the trigger and trigger level, the conversion fraction and the conversion terms (conversion ratio and conversion price).

The trigger

The trigger is the underlying variable whose level will determine whether conversion is going to take place or not. There are mainly 3 categories: market, accounting and regulatory triggers

Market Triggers: In this case, the trigger is a variable observable in the market as: the stock price, credit spreads, market capitalization, market debt-to-equity ratios, etc. Its advantages are mainly the availability of data and inclusion of future expectations (Spiegeleer and Schoutens, 2011a). However, these may be subject to market manipulation (McDonald, 2010). Spiegeleer and Schoutens (2011a) found that the delta of this CoCo goes above near 1 as the stock approaches the trigger, which could trigger a massive short sale and result in self-fulfilling conversion – death spiral.

Accounting Triggers: This time, conversion will depend on the magnitude of certain variables of the issuers financial statements. These include, for instance, the Core Tier 1 ratio, the liquidity coverage ratio and the leverage ratio. Although they present an objective view of the company (Sundaresan and Wang, 2010), they do not incorporate future expectations (Calomiris and Herring, 2011). Additionally, they may be subject to internal manipulation and also conversion may be lagged, due to the lack of data (Himmelberg and Tsyplakov, 2012). Most of the CoCo issues so far have a Core Tier 1 ratio trigger, as well as the one we will be studying in the following sections. Calomiris and Herring (2010) expressed additional concern about this trigger stating that Core Tier 1 equity is not a proper measure of loss absorbing equity while Risk-Weighted Assets do not measure a firm's risk exposure correctly. This is so because the

measure is more qualitative than quantitative: risk-weights are attributed according to asset class and not due to the actual asset volatility.

Regulatory Triggers: In this case, the regulator decides whether to convert the CoCo or not, depending on its individual assessment of the issuer and/or the market context. When included with other triggers, the regulator may declare the conversion should take place base not only on different firm variables but also depending on the state of the market, removing lag concerns about accounting triggers, for instance (Spiegeleer and Schoutens, 2011a).). However, the regulator may suffer market or political pressures when assessing its decision (McDonald, 2013), introducing undesirable trigger uncertainty (Himmelberg and Tsyplakov, 2012)).

CoCo's may also be issued with various trigger variables – as the proposal by McDonald (2013) – where conversion may take place when at least one is hit, or all the ones are hit at the same time, or any other combination. Both the triggers and their relationship must be designed carefully to ensure that conversion only takes place when the bank requires equity.

All in all, all the triggers have pros and cons. Concerning trigger accuracy when determining lack of capital, Veitberg et. al (2012) argue that market triggers have a higher probability of resulting in conversion when not needed (not harmful for financial stability) while accounting triggers have a higher probability of not forcing conversion when needed (harmful for financial stability). Most issues so far convert if the Core Tier 1 ratio (accounting) of the firm hits a predefined level and/or the regulator decides that conversion must take place (regulatory).

The trigger should be designed such that it is fixed, visible and transparent, in a way that investors can price CoCo's with more certainty when investing and to allow a market for such securities to grow (Spiegeleer and Schoutens, 2011a). By reducing trigger uncertainty, banks would also be more willing to hold excess capital as it can be effective in avoiding conversion (Himmelberg and Tsyplakov, 2012)). Lower triggers imply that conversion risk is lower, so the CoCo tax shield should last longer, being preferred by banks (Albul et al., 2010). Low triggers also increase the incentive to issue more CoCo's as the weighted average credit spread the company pays tends to go down, the bigger the CoCo tranche (Glasserman et. Al, 2013). A higher trigger on the other hand increases the likelihood of conversion, so banks should be more willing to issue equity on time, as long as conversion is not inevitable (Himmelberg and Tsyplakov, 2012)). Furthermore, the higher the trigger, the more the cost of debt should decrease with the issue as conversion is more likely, as a trade-off for banks (Glasserman et. al, 2013)). Setting higher triggers is also a way of ensuring that risk-seeking does not create firm value, at the expense that firms may not be willing to issue CoCo's on their own and regulatory imposition may be needed (Koziol and Lawrenz, 2011). Glasserman et. Al

(2013) argues that the trigger must be set above the default barrier (as capital requirements, for instance) to ensure that conversion takes place before bankruptcy, ensuring that managers risk management efforts can avoid dilution.

For the investor, the best trigger depends on the payoff at conversion which is mainly set by the conversion terms. If conversion terms are so that the investor expects to have an equity value higher than the value of the principal that converted, then it will have a preference for higher triggers as conversion becomes more likely and ask for lower yields in this case. On the other hand, if it expects the opposite, than the investor will prefer lower triggers in order to minimize the probability of conversion.

The Conversion Fraction

This defines the amount of the principal may be converted into equity.

Full Conversion: This means that the full amount of the CoCo is converted when the trigger is hit, implying that a CoCo holder will only have equity shares afterwards.

Partial Conversion: In this case, upon conversion, the CoCo holder will have a fraction of its investment in the form of a straight bond and another in shares.

Conversion in stages: In this case, the parts of principal are converted according to multiple trigger levels and can thus be seen as a basket of CoCo's. The bank will then be recapitalized in stages, as its condition worsens. This type of conversion fraction was proposed by Spiegeleer and Schoutens (2011b) as being also a way of diminishing the delta of the contract, mitigating the probability of the stock price falling into a death spiral, especially due to a firm having a stock price triggered CoCo on the capital structure.

Calomiris and Herring (2011) defends that the conversion fraction should be equal to 1 (full conversion) as it increases the penalty for shareholders of allowing conversion, thus reducing incentives for misbehaviour. Additionally, higher conversion fractions imply that more book equity is going to replace debt which is one of the main concerns of the regulator (Flannery, 2009). For the investor, the reasoning is the same as with trigger preference: if conversion is profitable, then a higher conversion fraction is also desirable. Otherwise, it will rather retain a higher debt claim and therefore prefer a lower conversion fraction.

The Conversion terms

According to Spiegeleer and Schoutens (2011a), the conversion ratio is the number of shares the CoCo investor is entitled to, in the event of conversion. The conversion ratio (C_r) depends on the conversion price (C_p) and on the conversion fraction (α - the part of the CoCo's that convert when the trigger is hit), in the following way:

$$C_r = \frac{\alpha\ CoCo}{C_p}$$

Thus, the CoCo investor is better off (requires lower yields) the higher the conversion ratio is: the higher the conversion fraction is and the lower the conversion price is. The value of equity a CoCo investor gets upon conversion will largely depend on the characteristics of these 3 parameters and their relationship.

Two main sorts of contracts can be set in this frame work. The first is that in which both the conversion price and the conversion ratio are defined at the start, while targeting a specific conversion fraction. As the number of shares is known, so is their dilutive effect. In this setting, the higher conversion price, the lower number of shares issued in event of triggering. Unless a CoCo of this sort is triggered by a market variable, manipulating the market is useless as the number of shares is already defined. The Llyods Banking Group (LBG) CoCo's featured a conversion price equal to the stock price at the time of the issue resulting in a relatively low number of shares in the event of conversion (Spiegeleer and Schoutens, 2011a). In this case, since the stock price is expected to be lower at conversion than at the issue, CoCo holders will be implicitly "paying" a premium for their shares. Essentially, if CoCo holders could buy any number of shares they could at the stock price prevailing at conversion using the principal, they could get more shares than they would get from conversion itself, and so they are forgoing value. Therefore, the conversion of LBG's CoCo is likely to transfer value from CoCo holders to former shareholders. If the contract is set such that the conversion price is expected to be lower than that at the time of conversion, then the transfer of value will likely go the other way around. While dilution is known from the start, the direction of the value transfer is not, even though it may be guessed as we did for LBG's CoCo.

The second contract type is that in which the number of shares will depend on the share price of the company at the time of conversion, in order to target a predetermined conversion fraction. Even though the amount of book equity to be issued at conversion is known from the start, dilution is not. Assuming that investors are rational and have full information (Koziol and Lawrenz, 2011), if the agreement states that the conversion price is exactly the stock price at conversion, then the number of shares will not result in a transfer of value. On the other hand, by establishing a premium (discount) over this price, the issued shares will lead to a transfer of value from CoCo holders (equity holders) to equity holders (CoCo holders). This is so because the investors, taking conversion as given, should find a steady state price that accommodates for this sort of dilution itself as well as any changes on expected future cash flows, cost of debt and cost of equity. In this sense, while dilution is unknown at the start, the direction of the value

transfer is. Conversion attributes CoCo holders a fixed market value of shares at the exact moment of conversion, equal to:

$$\frac{\alpha\ CoCo}{(1+\gamma)}$$

where γ is the percentage discount ($\gamma < 0$), premium ($\gamma < 0$) or par from the stock price at conversion at which the new shares are issued.

Behavioural deviations before conversion and afterwards as well as the degree of information the investors have will determine whether the CoCo investor profits and if the transfer of value is actually successful. We see that within this sort of contract, there is a great potential for market manipulation, as shareholders would want to have the share price as high as possible to minimize dilution while CoCo holders would want to push the share price down to be awarded with a higher number of shares. Therefore, we argue that these sort of contracts should be accompanied with both a floor conversion price (in favour of shareholders) and a roof conversion price (in favour of CoCo holders) to minimize the incentives for market manipulation and creating limits to dilution in both directions. Additionally, by using an average stock price of previous trading days the effect of market manipulation is minimized as it becomes hard to sustain an artificial stock price for a long period of time (Calomiris and Herring, 2011). In this sense, certainty about the conversion payoff should increase, promoting the marketability of the instrument. Credit Suisse's CoCo has a floor conversion price, in order to avoid unlimited dilution (Spiegeleer and Schoutens, 2011a), while also limiting the death spiral problem (Veitberg et. al , 2012).

Concerning information, if shareholders did not take conversion as given before it took place, the stock could be trading at a different value than that of the steady state price. While the effect of lower leverage should increase the value of equity as a whole, the number of shares resulting from conversion will determine the profit or loss for the former shareholders or CoCo holders.

As we have mentioned, academics favour CoCo's whose conversion transfers value from shareholders to CoCo holders. Glasserman et. Al (2013) state that those which attribute a fixed market value of equity (variable conversion price and conversion ratio) are preferable as the transfer direction can be better defined at the start, even though there is still concern about market manipulation. Himmelberg and Tsyplakov (2012) defend this type of CoCo's should also lead the company to persue more conservative capital structures. In their model, they showed that the weighted average spread of the company's debt should go down when replacing straight debt with CoCo's, and they should decrease more, the higher the dilutive effect. The authors

further argue that these CoCo's can mitigate the debt overhang problem as in the presence of CoCo's, the issuance of equity near the trigger also creates value for shareholders while the benefits to issue equity are higher, the higher the conversion ratio is. In this sense, the principal-agent problem is also mitigated, as shareholders are expected to fire the managers who let conversion take place (Calomiris and Herring, 2011). Still, Glasserman et. Al (2013) states that if managers decide to increase leverage excessively after the CoCo, the bankruptcy barrier may go higher than the conversion barrier, implying that shareholders may decide to default even before conversion, destroying the proper management incentives.

CoCo's whose conversion transfer value to shareholders create incentives for managers to destroy value near the trigger: by breaching the trigger, shareholders appropriate CoCo value, which may offset the cost of burning assets (Himmelberg and Tsyplakov, 2012). Koziol and Lawrenz (2011), went further and argued this last type of CoCo's may even be the start for the next financial crisis, as destroying value can become the optimal profit maximizing strategy – most of the CoCo's issued so far fall under this category. Pure write-down CoCo's (Rabobank's), high fixed conversion prices (LBG's) and floor conversion prices (Credit Suisse's) are examples limiting/denying CoCo holders from appropriating former shareholder value. Setting low conversion prices can also be a problem for banks due to negative signalling to the market (Calomiris and Herring, 2011).

The risk-seeking concern

The CoCo's success as an incentive driving tool will also depend on whether banks have discretionary power over where to invest or not. If they have limits to risk-seeking, then CoCo's are "unequivocally beneficial" as the probability of default goes down as well as distress costs (Koziol and Lawrenz, 2011). On the other hand, if banks can actually increase the overall risk of the company, managers may be tempted to increase the volatility of assets when the company is close to the conversion trigger (Glasserman et. Al, 2013) either to force conversion of CoCo's that benefit shareholders (an alternative to burning assets) or to avoid conversion of CoCo's that harm shareholders (an alternative to issuing equity and proper management). Koziol and Lawrenz (2011) expressed their further concern about the fact that CoCo's impose less discipline than straight debt since shareholder value in the bad state is diluted instead of being wiped-out and control rights being transferred to bond holders. In this sense, they care less about conversion than default and therefore they relax their risk management policies and/or have incentives to risk-seeking more than they would without CoCo's. As a consequence, both the probability of financial distress and bankruptcy costs are higher than without CoCo's, potentially creating the setting for the next financial crisis. Still,

Glasserman et al. (2013) found that such only takes place near the trigger, as the overall sensitivity of equity to volatility goes actually negative when the trigger gets very far from the conversion level, diminishing risk-seeking incentives even more than when the capital structure as straight debt in the place of the CoCo tranche. The authors defend that roll-over costs are the main driver, especially when the remaining debt is short term. Additionally, they argue that such risk-seeking incentives should diminish after conversion in case the trigger is set above enough from the default point, as default discipline is re-established. Himmelberg and Tsyplakov (2012) suggested that extra securities should be issued at the same time as the CoCo to minimize this problem. Koziol and Lawrenz (2011) suggest the issuance of CoCo's simultaneously with straight convertibles or with "rating-triggered" features in order to disperse risk-taking incentives, but advises for further research on the policy. The way that regulators account for risk through the measure of Risk-Weighted Assets for the Core Tier 1 Ratio is also not enough to limit the banks investment criteria (Calomiris and Herring, 2011). If investors have full knowledge about risk-seeking by the firm, they ask for higher CoCo yields. However, the extra debt capacity still leaves room for increasing the value of the firm through tax shields and investments (Koziol and Lawrenz, 2011).

Marketability

Whether CoCo's will succeed as a security will depend on the willingness of companies to issue them and of investors to purchase them.

An investor willing to purchase a CoCo is exposing himself to various forms of risk (Chreditu and Xu, 2012): interest rate risk (before conversion, a CoCo is fixed income instrument), conversion risk (leads to a risk profile shift) and equity risk (as the holder receives shares upon conversion). In the event of conversion, the CoCo becomes loss absorbing, requiring a higher return than when it was a fixed income instrument. Coupons are also cancelled upon conversion, reducing the expected return. Therefore, the yields investors require when investing will depend on: the seniority of the unconverted bond; the probability of conversion (dependent on the trigger); the conversion terms and the value of equity. Most academics have found in their models that CoCo spreads are higher than straight debt spreads. The negotiation power of both sides when it comes to the designing the CoCo is key, as investors will push for more dilutive terms while firms will do the opposite. As we have discussed, if regulators ever enforce the bond, they would eventually support the investor side as this is also the one which should result in an overall greater financial stability and sustainability. Sundaresan and Wang (2010), however, expressed his concern that CoCo's whose conversion results in a transfer of value will lead to a multiple equilibrium problem both

in the CoCo's and the underlying stock, creating instability in the market. Albul et al. (2010) on the other hand believes that forward looking should avoid it, even though market manipulation may still take place.

The difficult design of a CoCo may create valuation problems for investors reducing interest in it, especially if additional clauses are included (callability, payout restrictions while there are unconverted CoCo's and so on). The harder to price, the harder to hedge, especially near the conversion trigger level, as the CoCo should behave like a straight corporate bond when conversion is unlikely and like equity when conversion is likely (Spiegeleer and Schoutens, 2011a).

Share price triggered CoCo's can lead to massive short selling as the trigger level is approached further pushing the price down and eventually leading to conversion (Spiegeleer and Schoutens, 2011b) – banks would not like this. Chreditu and Xu (2012) proposed methods to hedge such bonds with both CDS's and stocks, which could minimize this problem. Since some institutional investors may also be restricted to having only fixed income instruments in their portfolios, they will push the share price down when selling converted shares, hindering firm's desire to issue CoCo's (Koziol and Lawrenz, 2011).

All in all, even though CoCo's provide benefits of both debt and equity, most authors agree that banks will not issue dilutive CoCo's – the ones which regulators favour – on their own, since the tax shield and debt spread benefits do not compensate for the risk of dilution (Glasserman et al., 2013). Issuing them free-willingly when the bank is under debt overhang (Himmelberg and Tsyplakov, 2012) or in the middle of a crisis (Calomiris and Herring, 2011) is not very likely, as it should create value for bondholders at the expense of shareholders, essentially because the CoCo is very likely to convert.

The regulators will play a big part in the development of market for this asset class, as they can create legal incentives for issuing CoCo's in terms of capital requirements. Calomiris and Herring (2011) believe CoCo's can be an alternative to raising minimum capital requirements to the roof as this would result in excessive costs of equity and a steep contraction on the supply of credit. Due to the governance incentives that CoCo's can create, academics defend that the regulator should force banks to issue them with the proper parameter designs. Himmelberg and Tsyplakov (2012) defend that CoCo's should be present in every bank's capital structure at all times, which could be accomplished by imposing payout restrictions to banks which did not comply or by softening capital requirements to those who issue them. Additionally, banks with higher asset volatility should be obliged to have more dilutive, in compensation. The Swiss Too-Big-to-Fail proposal approved in September 2011 required the largest Swiss banks to hold 9% of Risk-Weighted Assets in contingent capital, but later the

Basel III committee disapproved the measure since it is a new asset class (Veitberg et. al, 2012). According to the literature, the biggest concern about this bond should be the risk-seeking incentives created near the trigger, as these could increase the probability of default of the issuer and put financial stability at stake. The regulator may want to wait some time to have actual feedback of CoCo performance and analysing securities which, when issued in parallel with a CoCo (Koziol and Lawrenz, 2011), reduce the profitability of risk shifting. Another motive of concern is about who the CoCo holders will be: if banks purchase each other's CoCo's, the conversion in one bank can force conversions in the remaining due to mark-to-market accounting (Veitberg et. al, 2012). Still, on July 13th 2013 the European Union put Capital Requirements Directive IV (Capital Requirements Regulation) into force, which allows contingent capital to be recognized as "Additional Tier 1 Capital", creating incentives for banks to issue CoCo's as a part of their compliance with the minimum capital requirements.

Rating agencies must also be willing to rate CoCo's as many investors turn to ratings when analysing investment decisions. Nevertheless Standard and Poor's estimated that CoCo issuance is expected to hit the $1 trillion mark (Spiegeleer and Schoutens, 2011a).

Valuation Models

There are mainly three groups of models created to price a CoCo: credit derivatives, equity derivatives and structural models. The credit derivatives models were pioneered by (Spiegeleer and Schoutens, 2011a) in which the authors priced a CoCo based on its spread, considering a trigger intensity analogous to a default intensity parameter. This type of models has been the least used by academics so far. (Spiegeleer and Schoutens, 2011a) also started the equity derivatives category based on the Black-Scholes method, in which they decomposed the value of a CoCo in three components: a coupon corporate bond, a knock-in forward (in order to determine the value of CoCo shares at conversion) and a stream of down-an-in binary options (in order to cancel the remaining coupons, after conversion took place). Equity derivatives models are directly built for CoCo's whose trigger is the stock price. By implying a conversion stock price for a Core Tier 1-triggered CoCo, for instance, Jung (2012) showed that the implied trigger is very volatile and trending, for which the Black-Scholes stochastic price assumption is violated. Yet this category of models is appealing for its simplicity. For variations of the model, see: Corcuera et. al (2012); Chreditu and Xu (2012); Jung (2012); Veitberg et. al (2012). Structural models were started in Flannery (2005), in which the author – and the followers – created a Merton-based model (see Merton, 1974), in which the company's debt and equity can be seen as options on the value of assets. In this sort of models, academics usually started by

simulating the value of assets, by assuming processes like Geometric Brownian Motion for the value of book assets, or some form of income to asset stream. Jumps in these processes are usually included to simulate the impact of bank runs, usually tend to render holding excess capital useless and therefore reduces incentives to do so (Glasserman et. Al, 2013). Dividends and asset sales have also been considered. Then, they usually assume a debt structure, which may include deposits and/or straight debt, and their processes by assuming roll-over costs and/or potential depositor withdrawal. Then they add a CoCo to the structure, usually comparing the cases of enlargement of the balance sheet, replacing straight debt or replacing equity. Then the authors test how a CoCo bond and its features may have an impact on managerial decisions in terms of optimal capital structure, risk-taking, asset selling and issuance of equity. The list of models includes: Himmelberg and Tsyplakov (2012); Buergi (2012); Koziol and Lawrenz, 2011; Glasserman and Nouri (2012); Glasserman et al. (2013); McDonald (2010); Albul et al. (2010); Barucci and Luca (2013); Brigo et al. (2013); Pennachi (2010); Flannery (2009). On the upside, this type of models allows for a great modelling space and to test the importance of the various CoCo components (Williams and Bethke, 2013). The downside is their high parameterization, requiring expert judgement in order to define the appropriate intensities of the processes. Williams and Bethke (2013), reviewed all the categories of models, stating that most approaches approximate the dynamics of CoCo pricing quite well, but points the fact the resulting hedging strategies would not work. These authors favour the equity derivatives approach for its simplicity and the few amount of parameters required for its use. As Core Tier 1-triggered CoCo's have been more common so far, structural models are likely to have a greater appeal.